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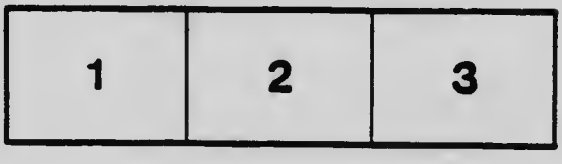

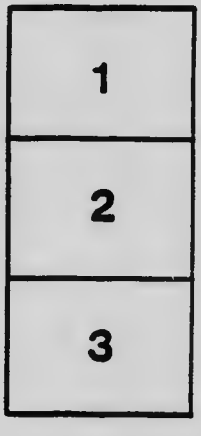

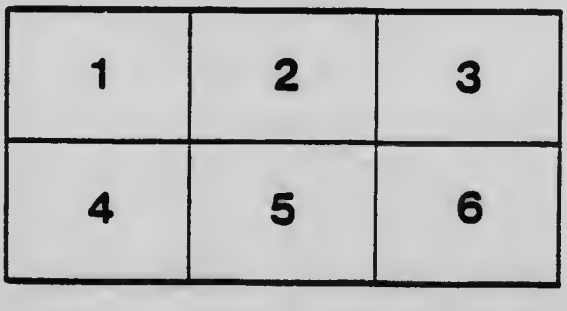

AN OUTLINE OF THE PHYSICAL GEOGRAPHY OF CANADA

BY

D. B. DOWLING

Reprinted from the Thirteenth Report of The Geographic Board of Canada.

OUTLINE OF THE

PHYSICAL GEOGRAPHY OF CANADA

Of the early American continent--its formation and subsequent outline, as it passed through the ages leading up to the habitation of the seas by living forms—we can form but a shadowy mental picture. Fragments of very early sediments are found, which indicate the presence of land areas; and in even the oldest of these there is a suggestion of the character of the material surface from which they were derived. Many interesting problems relating to the origin of these early beds have been solved; but in the search for the original crust all efforts have been vain. We must conclude, therefore, that the original crust or first consolidated land, as well as the first sediments derived from it, has been worn away from a large part of the continent; and where it has not been removed, has been entirely altered by contact with molten masses or by subsidence to zones of high temperatures. A comparatively stable continent can, however, be traced back to about the period at which the seas became habitable, or to the dawn of life on the planet. The continent, at the time of our first fairly clear conception of it had already passed through a long history; its mountains had been worn down, and the only topographic features of importance, except its outline, consisted of sears or depressions marking weakly-supported areas. Various changes in its outline, caused by subsidence and elevation, have been traced; but its early, though somewhat larger form, bore a distinct resemblance to the present continent. It extended to Greenland and probably to the Asiatic shores, but was not definitely connected to the South American land area.

The great erosion, which resulted in the general flattening of this old continent, exposed granites and other crystalline rocks which, while in a molten condition, had played their part in the destruction of the original crust. The general surface thus exposed may be likened to a mosaic in which the base, mostly of light-coloured plutonic rocks, is ornamented by the insertion of green and grey patches of sedimentaries, volcanics and various highly [illegible]ocks. This old surface which forms the basis of the present continent is g[illegible]rred to as the Canadian Shield. Its subsequent history includes a furth[illegible] of the surface by erosion, a deformation of its borders by tangential str[illegible] invasion of its surface by the sea when, during periods of crustal strain, [illegible]ortions were depressed. The occurrence of these periods of depression follow[illegible]y elevation is proved by the marine sediments now found on the continent. The entombed remains of once living organisms show a gradual change in the forms of life, sufficient, with the crustal movements, to form the basis for a chronological division of the time elapsed, sometimes estimated at thirty million years, since the beginning of life on the planet. During this time the continent regained its original area three times after equally long periods of instability: but during the last three million years there has been very little change in its outline, though in that time the Rocky mountains have been built and many of the channels through the Arctic archipelago have been formed.

The topographic features of the present surface of the continent admit of its division, in Canada, into several physiographic provinces. The exposed surface of the old pre-Cambrian continent forms one of the largest divisions and has been called the Canadian Shield, the Archean peneplain and in its southern portion, the Laurentian Highland. The mountainous country of the west constitutes the Cordillera, while the mountains of eastern United States, in their continuation across the border, form the Appalachian Highlands of eastern Canada. The Great Plains, with various subdivi-

sions, occupy the area between the mountainous area of the west and the great, roughened surface of the Canadian Shield. The St. Lawrence Lowland lies between the Laurentian and Appalachian Highlands. Within the borders of the Canadian Shield an area on the southern margin of Hudson bay has been referred to as the Clay Belt. It occupies a part of the basin that was submerged during the Glacial period and covered with a coating of clay which smoothed over its inequalities and concealed most of the underlying rocks. Since its emergence the surface has been but slightly altered by drainage channels cut across it.

THE CANADIAN SHIELD.

The portion of the pre-Cambrian continent whose exposed surface still forms a large part of Canada, has an area of about two and a half million square miles. Its northern border crosses the Arctic archipelago, the eastern lies beyond Baffin land and Labrador and reaches the depressed area occupied by the St. Lawrence river, a short spur or point crossing this valley at the outlet of lake Ontario to join the Adirondack mountains in New York. The southern boundary runs from the spur west to Georgian bay, skirts the north shore of lake Huron and sweeps almost entirely around the ancient depressed area occupied by lake Superior. The western edge, from the lake of the Woods and lake Winnipeg, bears northwest to the western end of lal. Athabaska, and passes through the basins occupied by Great Slave and Great Bear lakes, reaching the Arctic ocean east of the Mackenzie River delta. In detail, the surface features of the Canadian Shield are irregular; but, viewed broadly, it has the conformation of a great plain, depressed toward the centre and in the north and slightly elevated along the eastern and southern borders, where it presents a somewhat steep outward slope. The general elevation in the eastern portion is under 2,000 feet, and over the larger part of the plain is about 1,000 feet. The highest portion is along the northeastern margin where it presents a steep face to the sea. Its outline and section suggests faulting or a great fracture along the coast and a subsidence of the crust to the east of the fault. The northern border which passes through the Arctic islands shows great differential erosion, the result possibly of fractures and faulting. The great elevations found on the eastern shore of Baffin island, north of Cumberland sound, lie to the eastward of the supposed line of faulting parallel to the Labrador coast, and appear to be an elevated block lying in the fractured zone which now constitutes the submerged strip between Greenland and the Canadian shores.

On account of its hummocky nature, the surface of the Canadian Shield is dotted with innumerable lakes, the majority of which are rock basins. The surface being profoundly glaciated and most of the former debris carried southward, the present drainage is not impressed on the rock surface, but rather follows pre-existing depressions and occasionally former drainage channels. Remnants of these old channels, some of which are very ancient, are found near the border of the plateau, such as the Ottawa River channel, the smaller, Gatineau River valley, the depression through which the St. Maurice river flows, the deep channel of the Saguenay and the deep cut occupied by Hamilton inlet on the Labrador coast. In the case of the northern drainage most of the channels seem to have followed structural breaks; but the outlet from Hudson bay and such features as Chesterfield and Wager inlets have resulted apparently from erosion.

The effects of pressure folding, to which the outer edges of the old continent were subjected, are but faintly seen over most of this area. The various earth movements are shown here mainly in the records of subsidences and elevations which affected portions of the area and allowed recurring invasions by the sea. The greatest subsidence was probably during the Trenton period, about the middle of the Palæozoic era,

when the form of the continent was for a time greatly changed. The area under consideration consisted then of four islands, namely:—

(1) The eastern part of Baffin island which was joined to Greenland.

(2) The larger part of the Labrador peninsula.

(3) An area north-west of lake Superior which extended to the Nelson River depression.

(4) An area west of Hudson bay and east of the Mackenzie valley.

These portions of the Canadian Shield appear to have remained above the sea from a very early period.

At the beginning of Devonian time these islands were probably rejoined; but a depression remained to the west and south. At the close of the Devonian period, an elevation of the northern edge of the continent, which progressed southward throughout Carboniferous time, caused the sea to retreat slowly southward from the depression.

The basin now occupied by Baffin bay was probably not formed until after Cretaceous times, since the trap overflows now found along the Greenland shores which are probably evidence of the crustal movements of the time, are of Tertiary age. The latest continental movement, which effected this area in a slight degree only, was a depression during the Glacial period, followed by a partial recovery after the removal of the ice mass. This is shown by modern beaches and marine-clay plains now above the sea, in the lowlands and in the Clay Belt south of Hudson bay.

THE CORDILLERAN REGION.

The western part of the American continent is more or less mountainous. The Andean chain which extends throughout the length of South America, broadens out in North America and, in Canada, has an average width of over 500 miles. This region is the most elevated in Canada, many of the summits reaching heights of 10,000 feet, with occasional peaks over 13,000 feet above sea-level. The mountainous tract forming the Cordillera can be divided broadly into three parallel bands: an old series of plateaus and mountains forming the central part, referred to as the Interior System of Plateaus and Mountains, a young series of parallel ridges, east of the central plateaus, formed of fault blocks and folds and known as the Rocky mountains, and a third division, between the plateau country and the Pacific, called the Coastal System. This system consists of two topographic divisions: a granitic ridge or mountain range, which borders the coast, and an interrupted range forming the mountainous Vancouver island, the Queen Charlotte group and the islands of the archipelago at the north-western corner of British Columbia.

The interior system of plateaus and mountains has had a very long history of elevation and subsidence, resulting in alternating periods of denudation and deposition. The Rocky mountain system is more modern and its ridges show very little erosion except the removal of the debris caused by the earth-fracturing. The Coast system is slightly older than the Rockies, having undergone considerable erosion before their elevation.

Historical Note.

The central part of the Cordilleras has long been a topographic feature of the continent, having a history extending almost as far back as that of the Laurentian plateau. No land areas of this remote date are preserved; but rocks formed from the debris of this land remain and give evidence of having been in turn subjected to intensive erosion which almost entirely removed them and formed from their debris the deposits in which are found the earliest forms of life. These deposits were raised

above the sea in early Palæozoic time and in turn formed a land area on which the sea encroached during Carboniferous times. The close of the Palæozoic was marked by a shallowing of the sea, which separated this ridge from the Laurentian plateau to the east, and a general elevation of the land. This elevation was possibly more pronounced throughout the region now occupied by the Coast range, as, in Jurassic time, the sediments forming the outer crust were ...ised by the injection of molten granite beneath. Volcanic activity followed this great movement and outflows of this period are to be found on both sides of the mountain range then formed. A subsidence of adjacent areas is marked by deposits of early Cretaceous age; but in the interior, the latter part of the period is marked by denudation and levelling of the surface; and in the Coast range, by the removal of most of the stratified deposits overlying the granite batholith. The last invasion of the continent by the sea occurred during this period, when the western portion was separated from the eastern by the Cretaceous sea.

The close of the Cretaceous introduces a great period of elevation, not of the coastal area but of the interior belt and the part now occupied by the great plains. The continent then began to assume the outline it has at present. The further denudation of the Coast range and its dissection, the deep trenching of the plateau country and the forcing up of the ridges constituting the Rocky mountains were the principal occurrences. The period generally assigned to the building of the Rocky mountains is that covering the close of the Eocene but has been termed the Laramide revolution. Although volcanic outflows covered great tracts of the interior during this period, the violence of the crustal stresses were mainly spent in the formation of the Rocky mountains. A variation of the many periods of erosion and change of form was introduced in the Glacial period, when, owing to climatic changes, a great mass of ice spread in thick streams down the water-worn channels and over the lower rugged summits, smoothing their outlines and deepening and widening the valleys.

The Rocky Mountain System.

The Rocky Mountain System embraces all the ranges lying to the east of the remarkable valley called the Rocky Mountain trench, which extends from the United States boundary into Alaska. All along this strip the mountains maintain a remarkable uniformity in structure and are youthful in outline. The belt narrows and is considerably lower where it is cut by the valleys of the Peace and Liard rivers, but broadens northward by the addition of other ranges. The system includes: the Rocky mountains proper, which extend from the international boundary to the Liard river; the Mackenzie mountains, lying between the Mackenzie valley and the Yukon plateau; the Franklin mountains, a narrow ridge east of the Mackenzie river; and the Richardson mountains, near the Arctic ocean.

THE ROCKY MOUNTAINS.

On the basis both of form and of structure the Rocky mountains are divisible into two parts: a western and an eastern part. The axial ranges constituting the western part have been carved from a slightly-folded but greatly-elevated block, the denudation of which was probably inaugurated before the eastern ranges were elevated. The eastern part is made up of monoclinal blocks composed of beds that are generally of later formation than those of the western part of the mountains.

The eastern ranges, in a topographic sense, are merely blocks elevated to successively higher elevations than those of the foothills and from which nearly all the later and softer beds have been removed, exposing the more consolidated Palæozoic sediments beneath. These ridges, in contrast to the country of the central part of the

Cordillera, are veritable rock ridges, mostly grey limestone, not masked by a covering of sands and clays on which dense forests could grow. The fault blocks of which they are composed are, as a rule, tilted westward and along their eastern, scarped faces remnants are found that show the bending that occurred in these hard beds before the final break and overthrust of one block on the downturned edge of the one in front. The plane of the overthrust is frequently inclined to the west and this tilting is taken to indicate that the direction of the strain was from the west. The fault at the eastern edge of the mountains is often of this character, and the amount of overthrust, although great in Montana, is smaller in the Canadian ranges. In southern Alberta, on the British Columbia boundary, the Palæozoic limestones of the watershed range overlap the Cretaceous sandstones and shales which are found on the western edge of the fault block tilted up to form the Livingstone range, and several blocks of limestone are there stranded in somewhat the same manner as a block of ice on a shore. Crowsnest mountain is one of these remnants, being a limestone mass reposing on rocks younger than itself.

The similarity in outline of these ridges is the result of a general uniformity of dip and composition in the beds. The western slopes are very uniform, following generally the bedding planes of the rocks; but on the eastern slopes or those near the fault planes the slopes are often abrupt. Local glaciers have, moreover, etched this face into cirques and thereby contributed to the irregularity of the crest line.

The western ranges, or those near the watershed, are in contrast to those to the east in that they stand in higher masses, have more massive bases and have more elevated, glacier-clad summits. The scenery is of an alpine character; the small cirques found along the face of the ranges give place to great amphitheatres, such as those in the vicinity of lake Louise at Laggan.

The history of the ranges dates back to the appearance of low ridges in Jurassic times, representing the western part of the Rocky mountains, but the major movement of the crust is thought to belong to the Oligocene.

THE MACKENZIE MOUNTAINS.

This part of the great Rocky Mountain System constitutes the greatest mountain group in Canada and consists of several ranges, which can be divided into two groups in the same manner as the ranges of the Rocky mountains proper to the south.

The western part is the result of an older uplift and bears evidence of long-continued differential erosion. The eastern ranges are newer and bear a direct relationship to the eastern ranges farther south; their structure is due to the faulting, folding and buckling of the outer crust and they present the appearance of faulted and tilted blocks. The principal lines of fracture are in a northwest-southeast direction and the prevailing dip of the beds is southwest.

The actual divide is not the most important element in the relief of the region, the mountains in the vicinity of the watershed not rising higher than many of the groups situated at distances from it. The line separating the two topographic divisions appears to be to the east of the divide; and in the eastern or younger ranges may also be included the ridges lying east of the Mackenzie river known as the Franklin mountains. These, although not of great elevation, are prominent, as they are somewhat isolated and are probably due to the same great earth movement. An interrupted continuation of the system northwestward, near the Arctic sea, is also described as being of the typical Rocky Mountain structure.

The western border of this great mountain system has been placed by custom at the structural and erosion valley called the Rocky Mountain trench. This valley has been traced intermittently, through a course supposed to be continuous, from Flathead lake in Montana to the Yukon-Alaska boundary, a distance of nearly 1,500 miles. In

its course the depression is occupied by parts of many streams. The Kootenay river, rising in the Rocky mountains, passes southward through the valley; the Columbia rises in small lakes in the valley and flows northward in the trench, eventually leaving it to journey southward; the Fraser also, near its source, flows northward in it and farther down doubles southward.

The Peace river flowing through a gap in the Rocky mountains drains a part of the trench by two long north and south branches. The trench is next tapped by the Liard river which carries a small drainage from it to the Mackenzie river. Farther north the valley is occupied in part by branches of the Yukon and has been recognized in the Klondike country as a smaller valley entering the Yukon near Dawson.

The Interior System of Plateaus and Mountains.

The Rocky Mountain trench is the most convenient line of demarcation between the Rocky mountains and the Interior mountains and plateaus. Other great lines of erosion serve as boundaries for the subdivision of the mountain masses of the southern part of central British Columbia. The Rocky Mountain trench is thus the eastern boundary of the Selkirk system of mountains and the Selkirk valley is its western boundary. This system is further subdivided by the Purcell trench into the Purcell mountains and the Selkirk mountains. The Columbia System lies to the west of the Selkirk valley and extends to Kettle river, merging along its northern border into the Interior plateaus. The character of these two great systems is, in the main, of alpine type with deep valleys; the general summit level is from 6,000 to 9,000 feet above tide. The Cariboo mountains form another unit, standing above the plateau country. These are the several Gold ranges of early writers and are, indeed, of more economic importance from their metallic minerals than either the Rockies or Coast ranges.

The plateau country, viewed from the valleys by which the country is generally traversed, appears mountainous but, on examination from the upland, is found to have a generally flat summit level through which deep stream-valleys have been cut. That it has not been so dissected as to produce a mountainous topography is probably due to the comparative recency of the uplift that revived the streams and to the smoothing action of the general glaciation.

The great valleys that traverse the plateau country head near the Rocky mountains and find their outlets to the sea through the Coast range, by the cañons of the Fraser, Skeena, and Stikine, and northward, around the mountains, by the Yukon. There is also an eastward drainage through the Rocky mountains, by the upper branches of the Peace and Liard rivers.

Remnants of former drainage channels are also found and are occasionally prospected, as are the present channels, for alluvial gold. The wearing down, shifting and sorting of the debris from this old land surface has concentrated the gold derived from some of the old rocks and placer gold is now being obtained from the river beds of the Fraser and its branches, in the Cariboo country and from streams in the Yukon.

Lake basins, evidently on old drainage channels, are also a feature of the plateau country. Lakes such as the Shuswap and Quesnel lakes which occupy narrow, irregular basins in the plateau country, and the Kootenay, Arrow and Okanagan lakes in the southern mountain region belong to a former erosion period.

The Coast Range.

This belt of mountains is generally from 60 to 80 miles in width, and is a deeply-dissected, granitic mass or batholith, in which the summits near the sea stand at elevations of 4,000 to 5,000 feet. Near the axis of the range the summits are found at elevations of 7,000 to 8,000 feet. The mountains are massive, with steep, often craggy slopes and rounded dome-shaped summits. The heights are fairly uniform, with a few isolated peaks rising above the general level.

The valleys are deep and steep-sided and penetrate the ranges in all directions. Glaciers are numerous, especially in the higher latitudes, and occupy the upper portions of the valleys. Dense forests clothe the lower slopes to an elevation of 4,000 feet. A fiord system indents the range, which resembles that of Norway though it is on a grander scale. The deep dissection of the range during a period of greater continental elevation may have been influenced and aided by structural fractures, but the larger penetrating valleys in some instances point to the existence of drainage channels which date back to nearly Cretaceous times, or at least to a period which is almost as remote as the building of the mountain chain. The typical rounded summits of the hills and the steep-sided valleys are the result of a profound glaciation, by which the original rough peaks and valley trenches have been modified.

The dissection and subsequent subsidence and glaciation has produced an exceedingly intricate coast line, in front of which groups of islands are separated from the main land and from one another in many cases by deep, narrow channels. These channels are of value as highways of commerce along the coast, providing long stretches of sheltered waterways for the coastwise trade.

The rugged mountains rising steeply in close proximity to the navigable channels, their sides clothed with dark fir and cedar and their summits topped with glacier or rock mass, form a most impressive picture.

The large drainage channels which cut the range at intervals serve as outlets for the drainage of the interior country. The principal channels are the valleys of the Fraser and Skeena rivers, both of which are traversed by transcontinental railway lines. The Fraser valley, which near its outlet is close to the United States boundary, originated in a drainage that had its inception in Cretaceous or early Tertiary times; and the delta deposit at its mouth which extends south into Washington is evidence of the active erosion of the plateau land of the interior. The valley follows a course influenced greatly by structural features. It was broadened, straightened, and smoothed by the scouring of a heavy glacial stream. A late period of activity in its erosion, due no doubt to post-Glacial uplift, is shown in the incision of a narrow rock channel in the old valley floor, leaving rock benches above the present stream and gorges or cañons at the steeper gradients.

The Skeena valley, which is broad through much of its upper course, narrows in its traverse of the Coast range. It is there a steep-sided trough, of the same type as the fiord depressions along the coast; but, in contrast to the Fraser, it has not been revived by post-Glacial uplift and, for fully 40 miles from its mouth, is fiord-like. Above this, for 30 miles, the valley is silted up and the stream flows through an alluvial flat. Glacial deposits are found farther up, through which the stream is still actively eroding a channel. In places, however, these deposits have been removed and, for some distance west of the eastern edge of the coast range, the rock floor had been attacked and rock-walled cañons are found, where the steeper grade makes navigation difficult. The mountains in view along this channel do not reach high altitudes; they show the effect of the great glacial stream that moved coastward by this depression.

THE APPALACHIAN REGION.

The mountain system of the eastern portion of the American continent is by no means so imposing a feature as the system of the western region. Through the southeastern United States two parallel chains, side by side, divide the interior basins from the Atlantic seaboard. North of the Hudson river less regularity in form and structure is found, and the Appalachian system is represented by the Green mountains of Vermont, and the White mountains of New Hampshire. The continuation of the Green mountains into Canada may be traced in the Notre Dame mountains, which approach the St. Lawrence below Quebec and, continuing with more easterly trend, form the highland of the Gaspé peninsula. Over a large part these hills hardly attain

the dignity of mountains, but peaks rising 3,500 feet above the nearby coast are found in the Gaspé peninsula. The continuation of the White mountains is found in the highlands of Maine and New Brunswick, the continuity being shown quite plainly by the rock-folding and other evidences of the great earth movements which caused the topography. An additional ridge apparently forms the present province of Nova Scotia and although the highlands of that province in few places rise to elevations greater than 1,500 feet, the rock structure indicates that it was a mountainous country at no very remote geological period. It is difficult to picture the outlines to which this edge of the continent conformed throughout all the changes of level which have occurred, as throughout a long period of its early history—until the disturbances of Devonian time—land areas were not much in evidence. This period of disturbance was one of those in which the accumulated strains in the crust, due partly to shrinking and partly to shifting of load, were relieved by wrinkling along the front of the continent, forming the early land south of the depression represented by the St. Lawrence. The close of the Devonian period introduces to us evidences, in Gaspé and Nova Scotia, of land deposits containing plants, and we may assume that the present land areas were then roughly outlined, and that surface carving had begun. During the succeeding Carboniferous there was, apparently, a depression of portions of the new land below the sea and a slow recovery, in which probably a much larger land area was formed than at present exists, as is indicated by the occurrence of submarine coal beds.

The great earth movements which resulted in the faulting and folding of the crust appear to have passed their maximum before Cretaceous time and a period of subaerial denudation was then begun. The mountains of the pre-Carboniferous lands and the broken and fractured surfaces of newer date were slowly reduced, the higher ridges to a more rounded outline, and most of the region to a plain of low relief. This period of denudation extending through Cretaceous time had almost produced a mature topography when a revival of the eroding agencies was brought about in early Tertiary times by a general continental uplift. To this second cycle of erosion is due much of the diversified topography of the uplands of the present day. The Tertiary lowlands extend far out beneath the present sea, and the lower parts of the larger valleys, such as the St. Lawrence, Restigouche and Miramichi, like those of the streams of the Atlantic sea-board to the south, were drowned by a general subsidence of the coast before the advent of the great ice-cap of the Glacial period.

A partial recovery of elevation on the withdrawal of the ice-sheet is indicated by the ancient wave-built beaches and marine-clays containing an Arctic fauna that are found along the coasts at elevations of from 50 to 600 feet above sea-level. At Quebec, on the hills behind Château Richer, the highest gravel terraces are 600 feet above tide. On the St. Lawrence shore farther down the river, at Rivière-du-Loup, beaches containing marine shells are found at 370 feet above tide, showing the rising of the land since the invasion of the ice-sheet. At the present time, there is little evidence of any movement of the crust in any part of Canada.

The Appalachian Highlands of Quebec and New Brunswick.

The continuation of the Green mountains of Vermont northeastward through Quebec reaches the shores of the St. Lawrence about 100 miles below Quebec, and continues with a more easterly trend to the end of the peninsula of Gaspe. In Gaspe the range is called the Shickshock mountains, and farther south in Quebec, the mountains of Notre Dame. The altitudes seldom exceed 2,000 feet, and the topography may be said to be almost at a mature stage. The hills are a succession of northeast and southwest ridges cut by a number of transverse valleys. The highlands of western New Brunswick present the appearance of an elevated plateau, which has been extensively dissected, along with the Notre Dame mountains, after the general reduction

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Relief Map of

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of Tertiary times, owing to a late uplift of several hundred feet. It is not definitely known whether the main transverse valleys belong to the earlier denudation or were incised since the elevation of this plateau. The hilltops of this second upland range from 800 to 1,000 feet, a few residual points in the extreme south attaining elevations of 1,500 feet above tide.

The Highlands of Central and Southern New Brunswick.

In the north-central part of New Brunswick, a rough, elevated region, known as the Central highland, stands as an imperfectly reduced part of the great Cretaceous peneplain of the New England States. The region owes its superior elevation to the strength of the granites and gneisses of which it is composed. There is an apparent concordance in level of plateau-like remnants at elevations of about 1,700 feet, above which summits appear up to an elevation about 2,500 feet above the sea. The rock structure is impressed on the topography mainly in northeast and southwest trending ridges and a border or belt of foot-hills of moderate relief carved from the surrounding slates and sandstones. A similar highland at lower surface elevation and of restricted area, is found in the southern part of the province, near the Bay of Fundy.

The Highlands of Nova Scotia.

The greater part of the peninsula of Nova Scotia is underlain by a complex, consisting of granitic masses intruded into highly-folded slates and quartzites that at one time must have formed great mountain masses. This mountainous district, still reflected in the outline of the peninsula, had become reduced to base level by the close of the Cretaceous period, and at present the remains of this old peneplain form the highlands of Nova Scotia. The surface, which is undulating, slopes to the southeast, and instead of sharp peaks the points above the general level are rounded hills and ridges whose summits are only from 600 to 1,000 feet above the sea. An elevation in Tertiary times is responsible for a general re-dissection; and steep, sharply-incised valleys penetrate the higher parts of the plateau, while in the lower parts to the southeast, wide, shallow valleys are more in evidence.

The more resistant rocks once forming the mountainous parts of the Maritime Provinces now form uplands, with the higher summits projecting but slightly above the rough-surfaced plateaus on which they are found.

In a general way these highlands may be considered as forming parts of a sloping plane, which reaches its maximum elevation in northern New Brunswick, 1,700 feet above the sea, descends to 1,000 feet in southern New Brunswick, and is about 500 feet above the sea in Nova Scotia. If, throughout Cretaceous time when the surface was being reduced, the same direction of slope was maintained, it would be reasonable to suppose that lines of drainage would be established bearing a general southeast direction; and it has been proposed as a possible origin for the deep cut made by the St. John river across the hard rocks of the southern highlands, that one of these Cretaceous drainage lines was deepened during the Tertiary uplifts and drowned by the pre-Glacial subsidence.

The Maritime Lowlands.

The denudation of the Cretaceous peneplain during Tertiary time was most complete over the areas underlain by rocks of late Palæozoic age. These, being less resistant to eroding agencies, were rapidly removed, and along the eastern shore of New Brunswick and as far south as the highlands of Cumberland and Colchester in Nova Scotia, a Tertiary lowland was formed in which the topography is mature, the hills have easy slopes and the river gradients are slight.

THE GREAT PLAINS.

A great area, including many diverse features, lies to the east of the Rocky mountains. The portion that is included under the term Great Plains extends from the southwestern edge of the ancient surface forming the Canadian Shield, to the eastern edge of the mountainous region of the Cordillera. This area for long periods was below sea-level; but in its earlier history a large part belonged to the pre-Cambrian continent. To the west there may have been narrow land areas or reefs and into the troughs between was swept the great mass of debris derived from the disintegration of the old pre-Cambrian surface. The amount of material found in the beds representing these early periods of denudation is enormous; and at the time represented by the oldest rocks in which evidences of life are preserved, the land area which formed the western part of the continent had become worn down to an uneven plain such as we now have on the Laurentian plateau. The shifting of the edge of the continental area by the sinking or rising of this old surface can be traced in this area through a part of its history in Palæozoic and Mesozoic time. It seems certain that in early Ordovician time there was an advance of the sea from the Pacific; but in the part of the continent here considered there was a subsidence, and the advance of the sea was from the south. During Cambro-Silurian and Silurian times the sea covered an area reaching from the present mountains to the Winnipeg basin, as well as that now occupied by Hudson bay, the two seas being probably connected by an arm extending through the depression through which the Nelson river now flows. The subsidence during Devonian time carried the sea across to the Arctic by way of the present Mackenzie valley and the whole area under the Great Plains was beneath the sea. A recovery of elevation took place during Carboniferous time, and it is supposed that the sea retreated southwestward leaving a narrow shallow-water channel separating the new land area from the old British Columbia ridge. This received the debris from the new land but in the part underlying the area under consideration no great amounts were accumulated till the beginning of Jurassic time when the coastal disturbances in British Columbia were reflected in the inauguration of another downwarping movement that deepened the trough and admitted the sea from the north across northern British Columbia. The deposits carried to this basin in general went to form fine-grained black shales. Sandstone members appear in the lower parts at intervals, but generally the source of the material is believed to have been at some distance. At the close of the Jurassic, sedimentation became periodically rapid. Sands were washed into the basin and the surface elevation was maintained at or near sea-level, so that continental drainage replaced saline water in the basin. The higher land surfaces that were suffering erosion may have supported a land flora, but no evidence of this remains; the lowland, which was near sea-level during this period of slow subsidence, maintained an abundant vegetation which is consolidated into coal beds of great economic importance.

Mid-Cretaceous time is marked by mountain building, or other disturbances in British Columbia, and the movement eastward of large amounts of coarse material which covered the early forested regions in the lowlands. This was followed by rapid sinking of the crust and the sea advanced to cover nearly as large an area as it had in Devonian time. The western margin was subject to fluctuations; and one retreat of the sea, caused by an elevation of the country to the west, probably reduced the submerged area by half. This period of uplift lasted for a short time only and the sea soon resumed its former size. The close of the Cretaceous is marked by a general, slow uplift and this area rose, to remain above sea to the present time. The new land as it appeared above the sea passed through the first stages of erosion and the newly risen coastal plain, underlain by soft rocks, was rapidly worn away to the harder floor of older rocks beneath. These shore deposits which probably covered a wide strip of the Arctic old land to the northeast, were carried back into the shallowing brackish-

water Cretaceous sea and covered the old muds with sand and clay deposits. The material which entered this basin after the salt water of the sea disappeared at the end of the Cretaceous period, was deposited in fresh-water lakes, and in this period—the early Tertiary—a large part of the material deposited consisted of sand and light-coloured clay. Some of the material came from the west shore, originating in the British Columbia highlands; but much of the clay was probably derived from the disintegration of the Archæan rocks to the east.

The plains during early Tertiary times were being slowly elevated. The movement was more rapid in the west than in the east and a slope to the east soon developed. The apex of the elevation, which seems to have been caused by a compressive strain in the outer crust, was in the region of the Rocky mountains, and the continuation of the uplift there developed into great earth fractures and the tilting up of large blocks in parallel ridges. The debris from this newly-broken surface was probably moved eastward and strewn over the area of the present plains. As the denudation of the plains was also being accomplished, little of this coarse pebble material has remained except the beds found on the top of the Cypress hills and another small outlier on the Hand hills. Assuming that this material represents the debris of the mountain building, the date of this would seem to be about Oligocene time.

Part of the denudation of the Tertiary and Cretaceous beds which had covered the basin with great thicknesses of shale, clay and sandstone, may have been accomplished at this time, especially in the elevated region near the mountains; but the greater part was due to a general elevation in Pliocene times. The amount of material removed may be judged when it is considered that, in horizontal strata, the valley of the South Saskatchewan shows a thickness of 2,000 feet, from the bed of the river to the top of the Cypress hills. Just where the material was ultimately carried it is difficult to say, but it was swept away, a large part probably reaching Hudson bay; and the plains assumed largely their present form.

Many of the valleys of to-day are broad depressions formed in pre-Glacial time, and some of them show old stream gravels covered by boulder clay.

The advance of the ice-sheet was from the north and northeast and the material carried by the ice was spread in a mantle of drift which extended to near the mountains. A general smoothing of the area probably occurred; but in Manitoba the edge of the Cretaceous plateau, which was deeply serrated by easterly-flowing streams, was steepened by the shearing action of the ice as it was deflected southward along the face of the plateau.

The question of the limit of the extension of the ice-sheet westward is still an open one; and the glacial till of the western part is believed by many to have been carried by floating ice. During the closing stage of glaciation the ice front held back large lake-like basins, of which the best known is glacial lake Agassiz which occupied the basin at the eastern edge of the Cretaceous plateau. This lake at first drained southward to the Mississippi. The retreat of the ice front lowered the water; but apparently the melting of the ice relieved the crust and allowed a general rise to the north, so that the lake continued to spill its waters southward over the rim of the basin until another outlet was provided to the north. This is unmistakably shown in the many beaches formed by the waters of the lake at its several stages. The upper beaches, laid down no doubt on an approximately level plain, now rise gradually toward the north. The lower ones, though curved, are tilted in less degree. At Winnipeg the lake, in its highest stage, covered the surface to a depth of 560 feet, and reached westward to near Brandon.

As many of the large drainage channels, such as the Saskatchewan river, were ice blocked during the existence of this lake, a large part of the drainage of the plateau entered the basin by the valley of the Assiniboine river. As a result of the valley cutting which ensued from this increased drainage, a great burden of fine-grained

material was deposited in the lower end of the lake and now forms the fertile land of the Red River plains of Manitoba.

The surface features of the great plains are quite diverse. The general conception of them as a vast area of level, treeless country is descriptive of the southern portion only; and even this portion is not without variety in its topography, since a large part of it is a northeasterly-sloping plateau of Mesozoic sediments, etched into somewhat irregular surface contour and overlapping a lower plain that meets the sloping and irregular surface of the Canadian Shield.

In the belt traversed by the railway lines a threefold division into prairie steppes, rising one above the other, is clearly recognizable, though the divisions are not distinguishable in the region farther north to which the term prairie is not applicable. For the purpose of description in the following pages these three divisions are adopted and a fourth is added for the broken hilly country of the foot-hills.

The first or eastern division comprises the plain lying between the Canadian Shield and the plateau formed of Cretaceous sediments; the second extends from the edge of this plateau westward to the erosion remnants of former Tertiary deposits; and the third stretches from this line westward to the foot-hills. North of the prairie country these distinctions are less noticeable, and divisions two and three become merged into one.

First Division.

The eastern division is the lowest in elevation and in Manitoba and northern Saskatchewan is essentially a region of lakes. It narrows up in the vicinity of lake Athabaska but widens northward to form the lowlands, through which the Mackenzie river flows to the Arctic. The drainage of the southern, narrow part is to Hudson bay, by the Churchill and Nelson rivers. This plain is underlain, generally, by gently-sloping beds of Palæozoic limestone smoothed over by a cover of glacial till. South of lake Winnipeg the till is covered by clays and silts deposited in glacial lake Agassiz. Thus was formed the rich farming land of southern Manitoba, where the extreme evenness of surface is noticeable because of the general absence of timber. This plain is, however, being partly forested by planting and by the natural growth which is taking place now that prairie fires are largely suppressed. The lake basins are due mainly to the removal of Palæozoic rocks from the older, westerly-dipping rock-surface.

In the Mackenzie lowlands the limestone ridges of the Franklin range divide the lower part. The western boundary of the plain southwest of Great Slave lake has not been very definitely fixed yet owing to lack of exploration and the supposed gradual slope from the plateau. The surface does not stand at great elevations above the large lake basins, and the eastern edge, where it joins the rough crystalline rocks of the Canadian Shield, varies in elevation but is highest at the head of Churchill river, where Buffalo lake is given an elevation of 1,330 feet. The slope eastward is gradual, the basin of Cumberland lake on the Saskatchewan standing at 870 feet. Lake Winnipeg, the lowest point on the Nelson river drainage of this plain, is 710 feet above the sea. From the highest point in this division, at the head of Churchill river, the slope north to lake Athabaska is the steepest found along the eastern margin, the descent being about 600 feet. Northward the slope is very gradual, as is shown by the Mackenzie river, which is navigable for steamers from the delta at the Arctic ocean to near lake Athabaska. The fall in this distance (about 1,300 miles) is about 550 feet.

Second Division.

The lower or eastern portion of the Cretaceous plateau is underlain by a succession of shale beds and other equally soft rocks that have been somewhat unevenly carved and cut by stream erosion. It stands at an elevation of about 1,800 feet above

the sea, or nearly 1,000 feet above the Manitoba lak The valleys are deeply incised, and one of them, now carrying a small stream, the Qu'Appelle river, at one time carried also the waters of the South Saskatchewan while its northern drainage was blocked by the Keewatin glacier. The drainage of the southern part is eastward into a confluent series of streams entering the Assiniboine valley and northeast into the Saskatchewan. At the edge of the plateau the major valleys are wide and thus divide the escarpment into several prominent hills overlooking the lake plain, known as Pembina, Riding, Duck, Porcupine, and Pasquia hills. Wooded areas occur in the northern part of the plateau and along its outer edge, while a few of the higher levels of the central surfaces are similarly covered.

Third Division.

This area, extending from the Coteau or the hilly country west of Moosejaw to the foot-hills of the Rockies, is divided by the depression through which the South Saskatchewan flows. To the north of this depression the drainage is mainly eastward to the Saskatchewan and northeastward to the Athabaska, while the region to the south includes a fringe of the drainage basin of the Missouri river. There is also, immediately west of the Coteau, a small basin without present outlet, whose waters evaporate in lakes Johnston and Chaplin.

The relief of this division is accentuated by the fact that much of it is bare of trees, so that such elevations as the flat-topped Cypress hills, standing 2,000 feet above the railway near Medicine Hat, and the Hand hills, 800 feet above the surrounding plain, become prominent topographic features.

Fourth Division.

The topographic character of the foot-hills is much more diverse than that of the other divisions. The geological structure is closely related to the topography, and all the hills are formed of folded or faulted rock masses.

Since the folding in these hills is due to the same causes that produced the Rocky mountains, the strikes of the folds follow directions nearly parallel to the mountain chains. Although many of them are of considerable elevation, the summits of the foot-hills are not as serrated as the mountains are, since the rocks composing them are softer. Their flanks, also, are either grassed or clothed with timber. In general arrangement they form a belt of varying width and elevation, consisting of parallel ridges cut here and there by streams rising in the mountains behind. The transverse valleys occupied by these streams are strongly-marked features and are probably ancient drainage lines as, in the outer zone of the foot-hills where the rocks are less folded, the valleys are very broad and the former plateau is represented merely by fragments separating the valleys.

THE ST. LAWRENCE LOWLANDS.

The southern interior of the continent consists of a plain of low relief, bordered on the east by the Appalachian mountains, on the west by the Cordilleran mountain systems, and on the north by the old surface of the Laurentian plateau. To the northeast this plain becomes reduced in width, and in the vicinity of Quebec is represented by a narrow plateau or shelf on each side of the St. Lawrence river. The triangular area beyond, in which is the island of Anticosti, is structurally related to the central lowlands. The underlying rock structures are comparatively undisturbed and represent great periods of deposition that were continued from the Cambrian to Devonian times.

Deposits of Carboniferous times, although not now found, may have originally occupied portions of the southwestern part of the district and have been subsequently removed in the long history of this part as a land area. It is believed that in the lower part of the plain 2,000 feet of beds have been eroded, and evidences of part of this sculpturing is found in the Monteregian hills, a remarkable group of rounded elevations standing as sentinels above the low plain, spaced at intervals of about 10 miles from Montreal eastward to the Appalachian hills. They are found to be ancient volcanic vents and laccoliths and on their surfaces still remain remnants of the rocks removed from the plain. These ancient volcanics indicate lines of weakness or fracturing, and originated, no doubt, during the late Palæozoic disturbances which were marked by igneous intrusion in the country to the east.

The St. Lawrence lowlands may be divided into three sections: (1) the St. Lawrence River plain separated from (2) the Eastern Ontario basin by a point of crystalline rocks, and (3) the Ontario Peninsula, a slightly more elevated plain whose eastern border is a steep escarpment, the eastern outcrop of a heavy limestone bed which underlies the western peninsula.

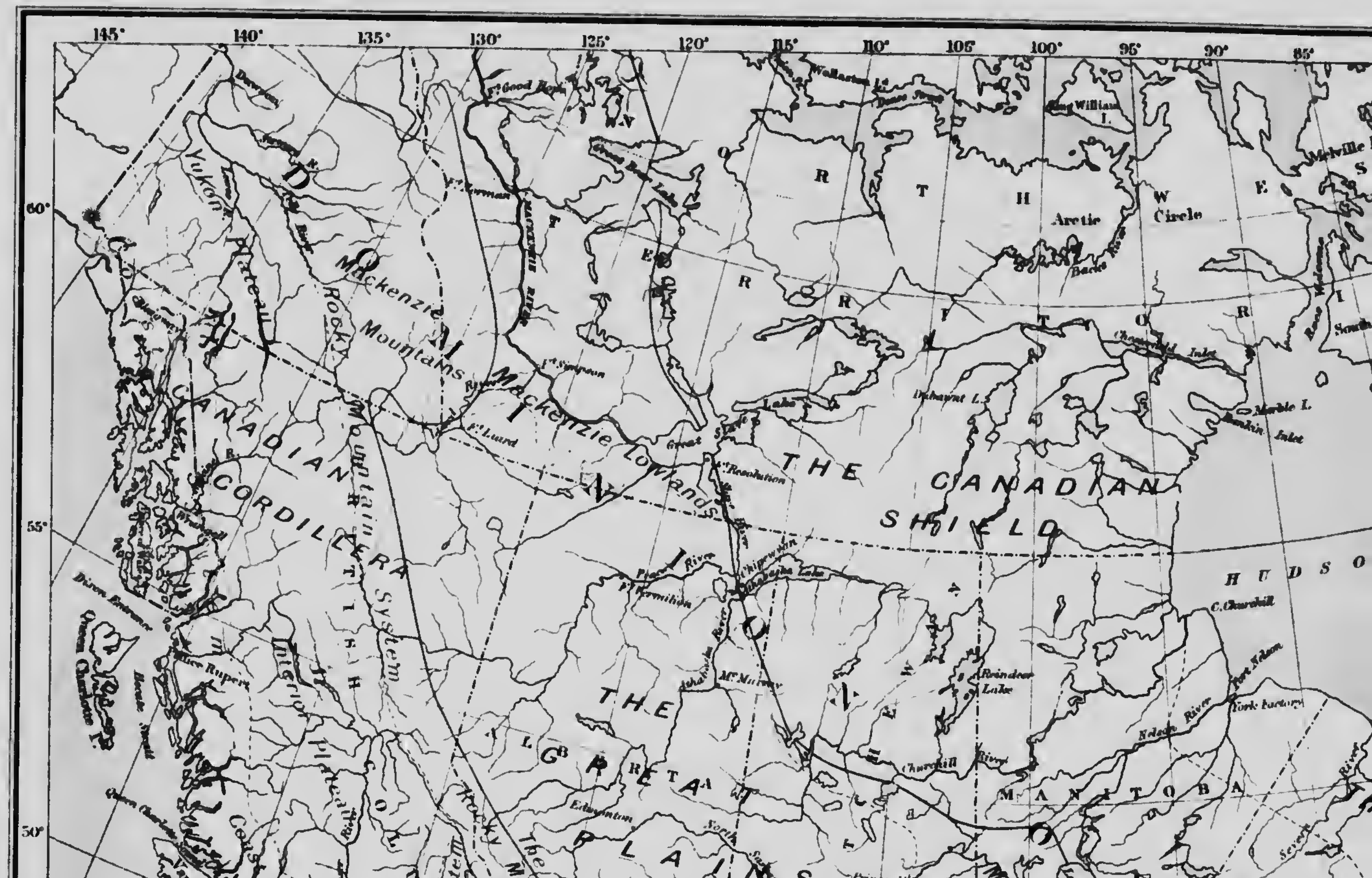
The St. Lawrence River plain occupies an embayment in the eastern edge of the granites of the Laurentian plateau. It is bordered by highlands on the east and west, but to the south by a belt of irregular somewhat rounded hills which form a connection between the Laurentian plateau and the Adirondack hills in New York. The southern part, from elevations of less than 500 feet, slopes to the northeast to a lower plain which, at Montreal, is 100 feet above the sea. The principal topographical feature of this part is the volcanic group called the Monteregian hills. These vary in elevation from 770 feet at mount Royal, on the west, to 1,755 feet at Brome mountain, on the east. The plain through which these hard rocks protrude is very even and is divided by the deep St. Lawrence channel as far as Montreal. Above this point, the two great rivers, which here meet, are still busily cutting into the rocks beneath and several very picturesque falls and rapids are to be found. On the St. Lawrence the channel is not as deeply or unevenly eroded as on the Ottawa, but is flowing over flat-lying beds so that the descent from lake Ontario is gradual, but the rapids are steep enough to cause exciting navigation in their descent and require the aid of canal locks for their ascent. The surface of the plain, once well forested, is now mainly under cultivation and owes much of its even outline and fertility to the mantle of glacial drift which was distributed while the area was submerged beneath the sea. Since the glacier disappeared the St. Lawrence lowlands have risen in altitude about 600 feet near Quebec, 560 feet at Montreal, and over 475 feet at Ottawa.

The Eastern Ontario basin is underlain by gently-dipping beds that are the lower sediments of the series constituting the Appalachian plateau farther south. This plateau in post-Devonian time emerged from the sea and formed a coastal plain along the south of the Laurentian hills. The erosion of the shore deposits soon developed a belted plain, owing to the unequal hardness of the underlying rocks.

Several of the outer ridges of the early series still remain. The inner ones are now merged into one major ridge, caused by the presence of a heavy limestone bed which has resisted the general erosion; and, in consequence, there has been a deflection of much of the old drainage from down the old sea plain to channels running parallel to the face of this ridge or cuesta, with a resultant intensifying of the erosion accomplished. There is thus a portion of this old sea plain which has been excavated through the softer surface beds, including one resistant member, to a harder series beneath. This excavation in its deeper parts holds the waters of Georgian bay and lake Ontario, while the slope to the old continental shore constitutes the eastern Ontario land area. The western peninsula is the portion between lakes Erie and Huron. In this there is a gentle rise from the lakes to the edge of the Niagara escarpment. The edge of the Appalachian plateau known as the Niagara escarpment is so called from the celebrated falls of Niagara which, in their early history, pitched

over the outer edge of the escarpment, though now, by their erosive action, they have retreated some distance from its face.

The history of the drainage of this area is somewhat obscure; but in its early stages it was probably mainly to the present Mississippi valley or into arms of the sea occupying parts of that depression. An early deflection of some of the eastern streams to a gap in the Appalachians took place, probably, in Cretaceous times and they were later deflected northward into the St. Lawrence valley. The present linking of the lakes into one chain is a further change, as it is believed that the principal line of drainage formerly followed the low ground below the Niagara escarpment; that is, the drainage of the upper lakes was across Ontario to lake Ontario. To the ice mass which covered this part during the Glacial period may also be ascribed some peculiar conditions which are now revealed by the beaches and channels. The weight of the ice no doubt depressed a large part of the surface of the continent and on its removal by melting, the recovery of elevation followed slowly and is shown in the beaches surrounding the present lakes at various elevations. The presence of the ice front also acted as a dam and changed the levels to a great extent. The drainage, when the ice had retreated past the present lakes and before the surface had risen to any appreciable extent, seems to have been divided, the Ottawa valley forming the outlet for the upper lakes and the St. Lawrence valley the outlet for lakes Ontario and Erie. A small elevation of the land closed the Ottawa outlet and for a time, possibly, its waters shifted to an outlet from Georgian bay to lake Ontario. Lake Huron, by the tilting of the crust, gradually extended south and its waters eventually spilled over into the Erie basin through the old pre-Glacial channel which they still occupy.



To accompany Physical Geography of Canada by D.B Dowling


Melville I.
Fox Land
Southampton I.
Coats I.
HUDSON STRAIT
Ungava Bay
Chimo
HUDSON BAY
THE CANADIAN SHIELD
Hamilton River
Hamilton Inlet
Cape Bauld
NEWFOUNDLAND
St. John
Anticosti I.
Eastmain River
Rupert River
Lake Mistassini
ST LAWRENCE RIVER
GULF OF ST LAWRENCE
Cape Breton I.
Sable I.
Abitibi River
Moose R.
L. Nipigon
Lake Abitibi
L. Timiskaming
Ottawa
Kingston
Toronto
LAKE ONTARIO
LAKE SUPERIOR
Sault Ste Marie
Laurentian Highland
Ottawa
Montreal
Quebec
St. John
Boston
LAKE HURON
LAKE MICHIGAN
LAKE ERIE
ST LAWRENCE LOWLANDS
APPALACHIAN REGION
NOVA SCOTIA
WISCONSIN
Detroit
Lansing
Chicago
Buffalo
Cleveland
NEW YORK
PENNSYLVANIA
Harrisburg
Philadelphia
New York
Boston
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